Report of the EIC Detector Advisory Committee
6th Meeting, January 13-14, 2014

BNL, in association with Jefferson Lab and the DOE Office of Nuclear Physics, has established a generic detector R&D program to address the scientific requirements for measurements at a future Electron Ion Collider (EIC). The primary goals of this program are to develop detector concepts and technologies that are suited to experiments in an EIC environment, and to help ensure that the techniques and resources for implementing these technologies are well established within the EIC user community.

On January 13-14, 2014 the EIC Detector Advisory Committee met at BNL to review nine progress reports that were presented concerning work from projects funded earlier; five of the reports also included proposals for additional funding, submitted in response to the fifth solicitation. Two reports from simulation efforts, one on detector response and one on physics events, were presented; both these projects are ongoing multiyear efforts. Four new proposals were also considered.

The Committee heard two presentations on the machine designs. Given the ensuing discussion, a future exposition on designs for polarimeters and luminosity monitors, and how they could be integrated into the machine lattices proposed, would be of interest.

BNL management also noted the central place that an Electron-Ion Collider occupied in the report of the recent NSAC Subcommittee on Scientific Facilities, chaired by R. Redwine, and on the expectations regarding the timeline for developing a new Long Range Plan for nuclear physics, in which an EIC could be expected to have a central place. The Committee members are: M. Demarteau (ANL), C. Haber (LBNL), R. Klanner (Hamburg), I. Shipsey (Purdue/Oxford), R. Van Berg (U. Pennsylvania), J. Va'vra (SLAC), G. Young (JLab, Chair). M. Demarteau was unable to attend the meeting due to a prior commitment for a HEP P5 meeting but transmitted his comments on several proposals including those for which he was an assigned reader.

General Remarks

The proposers are congratulated on the generally good quality of the talks, the focus of the work reported on key problems, and in particular on the extensive efforts to obtain the many results reported. The reports demonstrated in most cases responsiveness to prior charges and comments as well as ongoing dialog among proponents of similar technical solutions.

A report was received on the software tools being developed to support detector designs and study their response to various physics processes. The tools include a series of physics event generators for e-p and e-A, eleven in all, as well as a common interface to them which is supplied as part of a package to provide physics variables, appropriately smeared by expected detector resolutions, for input to a detailed simulation package for detectors. An analysis framework is available, EicRoot, that draws on the extensive code developed for FAIR, FairRoot. Both the ePHENIX and eSTAR LOIs discussing possible upgrades for an EIC made use of this simulation and analysis framework to develop and validate the designs therein. The

issues of releases, code management, user manuals and training, and interface updates were also addressed. It was encouraging to see definite assignments made of personnel to maintain various code packages. While many further developments are planned, the progress to date is most encouraging.

The Committee notes, as it has before, that this as well as the event generator effort reported under RD 2012-5 (presented by T. Ullrich, discussed further below) will be a "decadal" effort and will need sustained manpower. Those presently engaged in setting it up can be expected to move on to larger responsibilities as detectors are defined and their construction undertaken and as careers progress. A dialogue that has been ongoing between Lab management and the funding agencies could ensure a stable source of support for this effort. This will need to include computing experts who can address robustness of code and examine the same from maintenance and continuing support points of view, more so since one can expect continued evolution of the available computing environment.

The Committee notes the continued broad interest expressed in GEM detector technology and reminds the reader of its comments offered in the report for the meeting held in December 2012 and repeated here:

> The various groups should talk to each other even more.
>
> Is GEM foil stretching causing a risk that some copper holes' edges develop cracks and cause breakdowns? One group demonstrated an automated CCD-based scanner for GEMs. Could this be used after foil stretching to inspect all holes? In this sense TGEM might be a safer and more long-lived technical choice as it is not stretched.
>
> One should develop and then establish a standardized way to qualify GEMs for breakdown. One possible protocol could be to search for discharges using a 2D-scanning machine equipped with an alpha source; such an automatic machine would scan over all GEM holes, with the operator carefully monitoring current spikes.
>
> We encourage groups to consider the use of at least 4-GEMs for single photo-electron detection in order to handle discharges better; initial studies of this by other groups were encouraging. Using 5-GEMs might yield even better performance; one might consider 5-fold GEMs in order to reduce the gain per stage, which would mitigate problems due to highly ionizing ions entering the chamber on occasion. An effort to study these issues with the simulation tools now being developed is of interest.
>
> As an alternative to multiple GEMs, one might consider using a combination of "Micromegas + single Micro-channel plate". Recent development of large and cheap 20 cm x 20 cm MCPs could have low cost/unit area. The advantages are that these are thick, can be coated, and have a precise hole pattern, which is potentially much "cleaner" for UV detection applications than G-10 or Kapton. Study is required to determine whether electrons could be extracted from the upper surface were it coated by e.g. CsI, else one might have to add a window coated by CsI and extract photoelectrons from that. A dialogue is encouraged.

A quick check might be done whether occupancies permit using, instead of a pad structure, a wire chamber with resistive wire readout and charge division.

In anticipation of proposals expected for the next meeting, the Committee does repeat a few statements from the December 2012 report. Most proposals took care to state the requirements to be addressed by the proposed detector concept. Proposers need to include a discussion and tables of performance requirements and then discuss how their resulting detector specifications will produce a detector that meets them. Development of reference detector designs by the community will help this by providing an agreed-upon set of requirements and how they change for different regions, e.g. barrel, e-endcap, h-endcap, and beamline regions. Proposals should note whether the concept can work at eRHIC and/or MEIC, since the crossing rates are markedly different, and should also note whether the IR designs proposed are presenting any particular challenges for proposed physics measurements. This is an important part of an ongoing dialogue with machine designers. This discussion should expand in the future to encompass triggering needs, because these necessarily influence the design chosen.

A certain degree of definiteness is helpful to the Committee as it considers whether the team, resources requested, and activities proposed are adequate to advance the state of the detector art. Proposers should also discuss specific responsibilities and number of FTE of personnel, more so since a specific R&D effort is often not the main activity of a given group.

Measurements of neutron dose from the STAR IR were presented by the calorimetry group, with an encouraging level of agreement noted for certain locations; this can serve as a first threshold to rule out technologies that are especially radiation-soft. The Committee takes note of this nice result on a problem that will need continued study. The community needs to develop the understanding of the radiation dose and occupancy expected for each of the two machine proposals. Simulations must eventually include the full environment, including all detectors, shielding walls and the accelerator structure for up to ±100 m, to fully understand the dose. It appears the needed work to include this in the detector simulation package is underway. Detector proponents need to note the radiation dose their proposed technology can withstand and discuss where further knowledge is needed; this will require further effort by most proposers to date. The discussion about whether to support R&D on certain approaches proposed at this meeting hinges on whether the technology is adequately radiation-hard.

A general understanding of bunch-to-bunch variations of polarization and luminosity is still needed. A first proposal to study these issues was submitted this time (see discussion of RD 2013-6 below). A presentation on integration of the required detectors with the machine design was requested above.

The Committee expects there may be further proposals concerning silicon tracking and vertex detector development. It may be that a multi-institute consortium, such as is forming for the

calorimetry, will bring forward proposals in this area. The timescale for gaining the needed expertise for this technology, and for setting up local facilities to produce a tracking device to be installed in an EIC, is significant. The Committee took note that at least the ePHENIX LOI regards this as a future upgrade, tied to heavy-flavor tagging. The community should consider the approach here.

A few remarks about risk-taking again seem appropriate. The proposals and ongoing effort represent varying levels of innovation relative to established state of the art. It does not seem unreasonable to observe that all projects now underway should result in buildable devices on the timescale of a few years. The Committee notes however that the timescale for CD-0 approval of an EIC does seem to be several years out, and establishment of a formal reference design for the chosen accelerator complex would be expected to occur 1-2 years beyond that. At such a future time, detector proposals would need to mature and the scope of the R&D program in support of them would be expected to expand well beyond that of the present program, yet such latter day R&D would have a certain urgency to result in a buildable design that can be well estimated as to cost and schedule and thus might not have much of an exploratory aspect. In contrast, the opportunity and time horizon exist now to attempt R&D projects which may not *a priori* appear to have a high probability of success, yet would advance the state of the art.

RD 2011-1 Calorimeter Development for EIC
(H. Huang and C. Woody, reporting)

Two presentations were given:

a) Cal Progress Report and Proposal – Part 1, by H. Z. Huang, and
b) Status of EIC Calorimeter R&D at BNL, by C. Woody

In the first presentation, by H. Z. Huang, the following topics have been covered:

1. W-powder/scintillating fiber compact SPACAL EMC calorimeter

The production techniques have been further improved, and a tapered prototype for a test at FNAL in February to March 2014 completed. Some further improvements in the technology will be undertaken, however the basic production techniques are considered mature. Major changes compared to the prototype for the FNAL test are related to the way light is collected.

The committee takes note of the progress in construction techniques and is looking forward to the results of the FNAL tests.

2. Characterization of SiPMs

A test stand has been set up at UCLA, and open questions like optimization of bias voltage settings, and temperature effects were discussed. The plans are to continue these studies and compare SiPMs from different vendors.

Given the world-wide efforts and expertise on characterizing SiPMs and the number of running set-ups for SiPM characterization, the committee is surprised about the open questions raised. It appears that a closer interaction with the SiPM community would be highly beneficial for the project.

3. Readout electronics, calibration and gain stabilization

Good progress was reported on the SiPM front-end electronics, and module development, as well as on calibration and gain stabilization.

The committee takes note of the excellent progress.

4. Neutron background in the STAR Detector Hall

The comparison of measured and estimated neutron background shows that depending on the position in the hall they agree within a factor between 0.3 and 1.3. The studies will be continued.

The committee strongly supports these important studies, and encourages the community to use this information for the EIC detector background estimations.

5. Crystal R&D for a forward calorimeter at EIC

Simulations on the performance of a crystal calorimeter with respect to energy response, position resolution, shower shape and identification have been presented. With respect to improving the quality and yield of the BSO, no new results were shown.

The committee takes note of the status. It however is not convinced that the BSO development is a promising technology for an EIC detector. In particular issues like e.g. the effects of the slow component and the stability under radiation should be evaluated and presented to the committee.

6. Budget request for Part 1

The budget request is $115.1k, which includes overhead and indirect costs. Partial funding is proposed: full support for students' labor and the electronics engineer, and only partial support for sensors (to be coordinated with the BNL partners), materials and supplies, upgrades, and travel funds.

The second presentation, by C. Woody, covered EIC calorimeter R&D at BNL.

The committee has been informed about studies of the calorimeter design optimization using Monte Carlo simulations, the completion of an EMC calorimeter with fibers and flat W-plates with optimized light collection cavities for SiPM readout, calibration system, readout electronics and rotation stand for tests. After a test with cosmic rays, the calorimeter (EMCAL) will be characterized in a test beam in February at FNAL together with the sPHENIX prototype hadron calorimeter.

Future plans include an EMCAL test at SLAC, the further development of larger thin W-plates with the aim to build a 1 m long prototype module, the further development of the readout system, and tests of new SiPMs from Hamamatsu.

A year three funding request of $135k, including overhead, has been presented. The additional funding is not needed before May/June 2014.

The committee considers the program of high quality and importance. For the remaining funding a status report with an updated request should be submitted to the next EIC-RD meeting. The Committee is interested to hear the results of the beam test.

The committee is pleased to see the fruitful exchange of information between the two projects a) and b), and encourages an even closer collaboration.

RD 2011-3 DIRC-Based PID for EIC
(P. Nadel-Turonski reporting)

We heard a progress of R&D effort. This effort is done in collaboration with the PANDA experiment. The RD2011-3 group is proposing a design employing lenses at the bar end following with a large wedge, either filled with oil or made of Fused Silica, which will allow the Cherenkov imaging using x-y pixels, while time will be used as a secondary variable allowing the chromatic correction and the background rejection. This is a good direction in our judgment.

It will require understanding many details to reach a 6-7 GeV/c limit for the π/K separation. There are two major effects, both comparable in size: the chromatic error and so called "kaleidoscopic" effect, which is causing a resolution broadening and it is due to the squareness of the bar radiator, and shows up for photons in the Cherenkov angle wing (large ϕ). We would like to see more detailed MC study proving that the "kaleidoscopic effect" is removed by the new focusing optics. The chromatic effect can be removed by timing in DIRC-like devices. The "kaleidoscopic" effect needs to be removed by the optics, but this has to be proven.

If the photon camera will remain inside the 3T-field magnet, one will severely limit a choice of detectors. One option is to use SiPM-arrays and replace them after they become noisy due to neutron background. This time constant has to be tested (SuperB and Belle-II assumed a max. allowable neutron dose of 10^{10}-10^{11}n/cm^2). Probably a better option is to use longer DIRC bars and move the photon camera outside of the magnet, as DIRC did at BaBar.

The proposers did not request a new budget allocation at this meeting.

RD 2011-6 Tracking and PID for an EIC Detector
(T. Hemmick reporting)

The RD2011-6 collaboration is to be commended on a well focused and organized effort, with numerous achievements to its credit. The report and presentation was clear and informative and given in a form and style which greatly facilitated a clear understanding of status, plans, goals, and issues. Indeed, the report could be an excellent template for others.

Relative to the goals presented in June 2013, the collaboration has been very active, with the recent Fermilab test beam, utilizing a variety of structures, as a notable activity. The Committee took note that some 19 detectors, comprising 18K channels, were deployed, including beam vectoring and PID devices. We look forward to the continued and completed analysis of data from that. The results presented on zig-zag strips clearly merit a deeper analysis and understanding. Perhaps the use of precision metrologic tools to document better the structure of the electrodes would be of use. Figure 10 in the proposal is not particularly illuminating in this regard.

The idea to raise the first GEM grid to pick up the track segment ionization and then drift that to the electrode to extract the direction cosines was of interest. This may have difficulties for head-on tracks but already for incidence of 5°-10° appears to be a nice technique.

The RICH work is quite encouraging but the arguments for new mirrors and how that work would be organized were not yet clear, thus the Committee suggests revisiting that in a future meeting. The discussion of resistive division to accomplish charge division for the GEM readout might benefit from expanded noise analysis but is interesting to pursue at this point. The discussion of TPC/HBD needs better definition and should be revisited.

The scale of activities and budget proposed is large, and while likely doable by the team, may exceed the available resources. The group is to be praised for offering already to prioritize their goals. In this context we would agree to delay further the proposed mirror development work and descope other items, with support distributed as follows:

Fully support salaries
Core tracking: at 75%
Core mirrors: postponed
New hybrid gain: full support
New resistive division: full support
New TPC: defer to next Committee meeting to consider when funding may be more clear.

RD 2012-3 Fast and Lightweight Tracking Systems
(F. Sabatié reporting)

In this progress report, the proponents described in great detail work on a barrel tracking system using cylindrical shells of MicroMegas detectors and an end cap tracker based on triple GEM detectors. Very impressive progress has been made in starting work in the new laboratories and clean rooms at Temple University, including characterization of GEM foils and design of various mechanical structures. In addition, the effort at CEA on the barrel MicroMegas devices has moved forward both in terms of design of large MicroMegas tiles and also in the development of a new custom integrated circuit and first version circuit board, as well as development of ultra-low capacitance cabling.

The Committee was impressed by the high quality of the work so far and looks forward to the next progress report, which should include the ordering of large GEM foils and the initial characterization of a full size MicroMegas barrel element.

The proposers did not request a new budget allocation at this meeting.

RD 2012-5 Physics Simulations
(T. Ullrich reporting)

An excellent status report has been presented by Th. Ullrich. The main achievements so far are the completion of the implementation into *SARTRE* of saturated and non-saturated DIS, the completion of saturated and non-saturated exclusive diffraction, and the good progress on inclusive diffraction. The work on implementing *eA* interactions in *CASCADE* has been delayed in favor of implementing inclusive diffraction. In addition, in order to make *SARTRE* also available to the high-energy physics community, a grid based project to extend the phase space of *SARTRE* to LHC and LHeC energies is under way. In addition, the technical description of *SARTRE* has been published.

Next steps are the full implementation of inclusive diffraction and the extension of *CASCADE* to *eA* interactions. For achieving these goals, it is requested that an added $35K be allocated and the program be extended by 3 months beyond the approved end date of May 2014, to allow for a continuation of the employment of the post-doc.

The Committee was very much impressed by the high quality of the work and material presented, the excellent progress achieved and the impact this work is already having for the EIC and beyond. It agrees with the shift in priorities and fully supports the proposed 4-month extension of the program.

In the introductory talk by T. Ludlam the Committee has been informed that plans are under way for the long-term support and maintenance of the software for EIC simulations.

The Committee greatly appreciates these efforts and wants to be informed about the progress at its next meeting.

RD 2012-11 Spin Light Polarimetry
(D. Dutta reporting)

This proposal describes a novel polarimeter using the "spin light effect" to complement the accelerator polarization information that would be obtained by a standard Compton or Möller polarimeter.

The proponents have sharpened many of their arguments and answered some of the questions or worries raised by the committee at the previous meeting. However, one result of that somewhat greater clarity is to point out that, in this case, what is being proposed is, at some level, part of the accelerator system – a facility instrument to provide additional information about the state of the beam, rather than an intrinsic part of some particular EIC experiment or detector. Thus the immediate critical parameters are not so much how well the polarization can or would be measured, but how well such a device can or would fit into either (or both) an MEIC or eRHIC lattice. In addition, given the long integration time of the detector, the usefulness of the device has to be better understood. For this a discussion on various scenarios of bunch-to-bunch differences in number of electrons, as well as value and sign of polarization for precision EIC measurements in the broader EIC community will be required.

The proposal requests $97K to support the effort.

The Committee recommends continuing modest travel support ($10k) with the expectation that the proponents would work with either (or preferably both) the MEIC or eRHIC accelerator teams to understand how such a spin light polarimeter could work with the design of the particular accelerator, with the additional goal of including one or more of either or both machine teams as an active member of the Spin Light consortium. With a definitive lattice location and accompanying set of firm constraints in place it should be possible to more thoroughly and convincingly address the various questions raised on systematics, precision and accuracy by this extremely challenging measurement. The committee appreciates the additional calculations that refine the scope of the problem, but measuring asymmetries of 10^{-4} in the rate of spin-light photons under a synchrotron radiation background 10^{5} higher is daunting and unfortunately raises even more questions on possible systematic errors in the various matching terms. In addition, once one had at least one firm and fully plausible scheme in mind, then it should be possible to be significantly more quantitative about the benefit(s) of having a new and complementary measure of polarization for the success of the various physics measurements at an EIC. At that point a program to assemble and operate a test device would be well advised.

RD 2012-13 Pre-Shower Detector for Forward EM Calorimeters
(W. Brooks reporting)

A clear report on the prototype of the pre-shower detector for forward electromagnetic calorimeters has been presented by W. Brooks.

Many detailed problems of the detector construction have been solved, the MPPC readout including LEDs for calibration completed, the crystals received and wrapped, the light guides fabricated, the data acquisition prepared and the cosmic ray test stand completed. The prototype is now ready for a cosmic ray test and later for beam tests.

The Committee appreciates that the prototype construction has been completed essentially as planned. In addition to the test with cosmic rays, a test in a high resolution electron beam is strongly encouraged. The committee also notes that several comments raised in the two previous meetings have not been addressed, and requests that these be studied and answered, in particular:

1. It remains unclear if the concept can be developed into a large area pre-shower detector and the question of the ambiguities has not been addressed.

2. The performance of the concept in a real physics environment with emphasis on the shower separation in the presence of ambiguities has not been studied.

The proposers did not request a new budget allocation at this meeting.

RD 2012-15 GEM-based TRD for Identifying Electrons in eSTAR
(Z. Xu reporting)

This proposal addresses the development of detectors for electron ID in the forward direction using transition radiation in GEM chambers coupled with TOF and upstream tracking in the TPC.

The Committee heard a progress of R&D effort, and takes note of the progress on physics justification, some results from MC simulation and the first results from tests with small triple-GEM detector. The Committee would like to see more MC results simulating realistic mass in the TPC endcaps, TRD simulation with different foils, etc. The Committee would expect some test beam results, parameterizing various parameters such as the foil choice, the gas selection, the choice of operating point, etc. This will open up new questions, and provide a feedback for more detailed design evaluation.

The proposers did not request a new budget allocation at this meeting.

RD 2013-2 Magnet Cloaking Device
(Nils Feege reporting)

In an excellent presentation N. Feege presented the achievements and planning for this project, which was proposed and approved at the last meeting with funding started in Oct. 2013.

Several of the issues raised at the last meeting could already be answered:
- the *COMSOL* software has already been used successfully for similar problems,
- the expertise to properly run *COMSOL* and interpret the results is available in the consortium, and
- the permeability of the steel appears to have a negligible effect.

First steps towards a prototype construction have been completed:
- a cylinder with multiple layers of high Tc superconductor has been built,
- the cryogenic and room-temperature Hall probes acquired,
- the measurement set-up assembled, and
- test samples of stainless steel foils for the ferromagnetic layer of the prototype acquired and contacts to solid-state experts to measure and change the magnetic properties of the permeability of the steel established.

First measurement results, however at very low field (2 mT) are encouraging.

The proponents request $65K including overheads and fringe benefits for supporting a post-doc for 3 months and a graduate student for one year.

The committee is impressed by the rapid progress of this exciting project, and also appreciates the strong involvement of students. It is looking forward to the answers to the remaining questions posed at the last meeting, the results of the prototype measurements, the design of a realistic cloak prototype for tests in a beam line, and the exploration of possible other applications of the magnetic cloak.

The committee fully supports the additional funding.

RD 2013-3 Generic R&D (New proposal)
(B. Bilki presenting)

The presentation was given remotely.

This proposal describes several R&D projects that the proponents believe might be useful in the final design and realization of the Electron Ion Collider (EIC) detector systems. These are a secondary electron emission calorimeter, a zero degree calorimeter, and forward tracking with RPCs, and quartz based particle ID.

Secondary Emission (SE) calorimeter

In a Secondary Emission (SE) calorimeter ionization detector module, SE electrons (SEe) are generated from an SE surface/cathode/"dynodes", when charged hadronic or electromagnetic particles penetrate a SE sampling module either placed between absorber materials in calorimeters, or as a homogeneous calorimeter consisting entirely of dynode sheets as the absorbers**.** SEE produced in a thin metal oxide film on the inner surface of a metal plate in vacuum, which serves as the entrance "window" to a compact vacuum vessel is analogous to a photocathode are amplified by sheets of dynodes – metal-meshes or other planar dynodes. Detector modules have been built and two beam tests have been performed. The results of the first beam test at CERN in 2012 were not reported in the proposal but some were contained in the presentation. The analysis of the data from the second beam test at FNAL in November is ongoing.

Zero Degree Calorimeter

The proponents would like to investigate the possibility of optimizing a quartz fiber calorimeter, a quartz and scintillating fiber dual readout calorimeter, and a sampling calorimeter using doped/coated quartz plates and/or secondary emission modules for the EIC and propose a program of simulations to do so. No details are provided, however.

Forward tracking with RPCs

The proponents would like to investigate the possibility of utilizing RPCs in the forward region as an alternative to GEMs. RPCs have low rate capability of order of a few hundred Hz/cm2. To address this RPCs on low resistivity iron and copper vanadium glass are being developed. A prototype RPC built with this glass is shown in the proposal but no detail is given.

R&D for Quartz-Based Particle ID

The proponents would like to investigate the possibility of using quartz variants with a variety of dopants, thicknesses, indices of refraction and coatings as effective Čerenkov radiators that would be useful for particle ID both for the barrel and the forward regions of the EIC detector.

Funding request

The proposal requests $35K for the construction of a dedicated Secondary Emission calorimetry module with continuous lateral coverage, including readout electronics, for production and procurement of low resistivity glass for the RPCs. Funding is also requested for two half time graduate students for the simulation of the different design concepts contained in this proposal.

Recommendation

The proposal is very broad. Each of the projects suggested would require many man years of development work to achieve a proof of principle. There is no information about the resources available at the proposing institution to carry out the program proposed. Without this information it is not possible to fully evaluate this proposal and so the committee cannot recommend the proposal be funded.

There is already very active programs developing calorimetry and tracking for the EIC detector. The proponents are encouraged to talk to the consortia involved in this work to seek common interests and to determine if collaboration might be possible.

RD 2013-4 Forward RICH Detector (New proposal)
(Y. Qiang presenting)

Qiang gave an excellent talk.

The proposers presented a concept and R&D program for a Forward RICH involving dual radiators and a single radiator and various readout options. The goal of the proposal is to determine the detector technology and finish the conceptual design of the RICH detector in three years.

By using common readout a dual-radiator RICH detector has the advantage of a more compact size than two separate RICH detectors. Concepts of dual-radiator RICH detector for the EIC with focusing using a Fresnel lens and using proximity focusing are well-described as is a modular concept for aerogel RICH detectors where it is assumed that a separate gas RICH detector would provide high momentum hadron ID. Readout based on a LAPPD using an MCP is proposed. This would offer excellent timing resolution and would in principle significantly enhance PID capability. A GEM with a reflective photocathode film deposited on the uppermost surface as an alternative readout is also proposed.

Assuming successful completion of the work proposed, as a follow on project the proponents envisage producing prototypes of these RICH detectors for the EIC.

The proposal is well-structured. There are four related work programs.

Detector simulation and conceptual design

The detector simulations will be carried at Jefferson Lab and LANL using existing EIC simulation codes developed by other EIC projects, and focus on simulation of detector performance, optimization and optics design. The tasks include: modeling the aerogel, the lens, the strip or pixel readout, and to embed a detector in the EIC event environment, including tracking detectors, determine maximal pixel/strip size, maximum module size (for the modular concept), efficiency etc. and develop reconstruction software.

LAPPD photodetector evaluation

LAPPD samples and associated front-end electronics will be provided by the ANL group. Tests include single photon detection efficiency at different wavelengths, particularly between UV and green, Background noise level, gain as a function of input pulse rate, time and position resolution, radiation hardness, sensitivity to magnetic field, and lifetime Most of the performance tests will take place at Jefferson Lab.

Improvements to LAPPDs

Some characteristics of LAPPDs may need to be tuned in order to better match the EIC application. In addition to the good timing/position resolution and cost that the LAPPD collaboration is already pursuing the following areas have been identified: high rate capability, tolerance to a strong magnetic

field, a thinner glass window, readout ambiguity with high rate/alternative charge collection option. These developments and improvements will be mainly carried out at ANL.

GEM readout development for the Cherenkov detectors:

GEMs coated with CsI have been used to detect UV photons, but a GEM photocathode coating that is sensitive in the wavelength range appropriate for aerogel radiators (~ 300 – 500 nm) has not yet been realized on a large scale. The first phase of photosensitive GEM development will focus on optimizing photocathode deposition parameters and operating gases to give the highest possible effective quantum efficiency. CERN triple GEMs will be used for these studies that will take place at LANL. A suitable readout pattern will be developed in simulation, which can maximize ring resolution while minimizing channel count. This readout pattern will then be tested.

Aerogel development/characterization:

A variety of aerogel samples will be characterized to choose the best option for the EIC RICH. The work will be conducted at JLAb by personnel from both INFN and JLab, and some studies will be carried at LANL as well. The studies will include measurements of transmittance, absorption length and scattering length for different aerogel tiles, measurements of refractive index and chromatic dispersion, and high precision mapping of the tiles thickness.

Funding request

The proposal requests $359k. This supports post doctoral effort and some equipment and M&S across four institutions.

JLAB is responsible for the detector simulation, characterization of LAPPDs and conceptual design. Partial support for a postdoc is requested to perform these tasks as well as characterization of aerogel radiators under the supervision of INFN.

LANL will be responsible for GEM photocathode manufacture and testing, optimizing RICH readout design, and will simulate and optimize the proposed RICH detector in a realistic EIC environment. The labor funding will be used for partial support of a LANL postdoc for the project.

ANL is the home of the LAPPD collaboration. ANL will fabricate LAPPD samples for the project and also carry out the R&D of LAPPD needed to render it suitable for EIC RICH readout. The labor funding will be used to partial support an ANL postdoc for the project.

INFN will be responsible for characterization and selection of various aerogel samples. This work is conducted at JLAB where they provide partial supervision for the JLAB post doc requested above.

Recommendation

The proposal is very broad. Each of the four work programs would require many person years of development work. The proponents are highly accomplished and respected members of the

community with the relevant experience to execute the work proposed. The difficulty for the Committee is that the work proposed greatly exceeds the capacity of the personpower requested. Each proposing institution is a National Lab with significant technical resources and personpower, however the amount of personpower that can be assigned to carry out this work, beyond the personpower requested, is absent from the proposal. Without this information it is not possible to fully evaluate this proposal and so the Committee cannot recommend the proposal be funded at this time. However, with the addition of a full accounting of the personpower available to carry out the work proposed, the Committee would welcome a resubmission of this proposal.

RD 2013-5 10 Picosecond Time of Flight (New proposal)
(M. Chiu presenting)

This proposal seems to be well motivated and capitalizes on a critical and substantial development effort already in place for LAPPD devices. The Committee wants to encourage the proponents to continue to pursue this approach. The Committee suggests that the group reconsider and perhaps refocus its priorities here in light of two circumstances: a) the availability of components may be delayed with respect to their expectations and b) further optimization and considerations of characteristics and performance may result in a better targeted device relative to the EIC application. In particular

a) The Committee believes that an early focus on collider specific readout electronics, and fast timing, per se, may be premature. It is likely these aspects will become available in any case, as the technology develops further.
b) It is not clear that the devices sought for the early R&D will indeed be available on the timescale over which substantial funds are being requested
c) The configuration and characteristics may benefit from further optimization, some of which the proponents have already identified, and some which have been suggested by others:
    1. Optimization of wavelength response
    2. Pixelized versus Cartesian readout
    3. Area coverage of individual tiles
    4. Magnetic field effects

Given these recommendations and uncertainties the Committee recommends funding at a reduced level in order that the studies may be pursued, but also that more substantial funding be held to when it could be applied more decisively. In this regard the Committee would support funding one post-doc to focus on general detector issues as noted above, but hold off on the proposed electronics work. The Year 1 milestones, other than the PSEC5 aspect, should be followed but augmented with the more general suggestions under item c).

RD 2013-6 Electron Polarimetry and Luminosity Monitor (New proposal)
(E. Aschenauer presenting)

The proposers presented a description of the needs for beam polarimetry and luminosity monitoring and proposed a program of first simulation work to determine the detector requirements as well as interfaces with the accelerator both at the IR and elsewhere in the machine. This simulation effort would then be followed in some future cycle by an initial program of physical detector development.

It is absolutely essential to the success of an EIC program to have precision luminosity and polarimetry measuring devices integrated into the final machine design. This proposal represents a well thought out first step towards detailing the problem at least for an eRHIC design including a number of interesting possible detector concepts. Expansion of the effort to take account of the somewhat differing challenges posed by the MEIC design is strongly encouraged.

The measurement of the polarization of the electrons, as well as of protons and ^{3}He is absolutely central to EIC and will require a sustained major long-term effort involving machine and experiments. The Committee considers the proposal a good first step, however is of the opinion, that certainly in the longer run it is a Laboratory responsibility.

The proposal requests $135K/year for 2 years duration, principally for support of a post-doc assigned full-time to this effort, with a $10K/year allocation for travel.

The committee supports fully funding this effort.